Research Center

Power & On-Board
Propulsion Technology
Division

Wide-Temperature Electronics for Thermal Control of Nanosats

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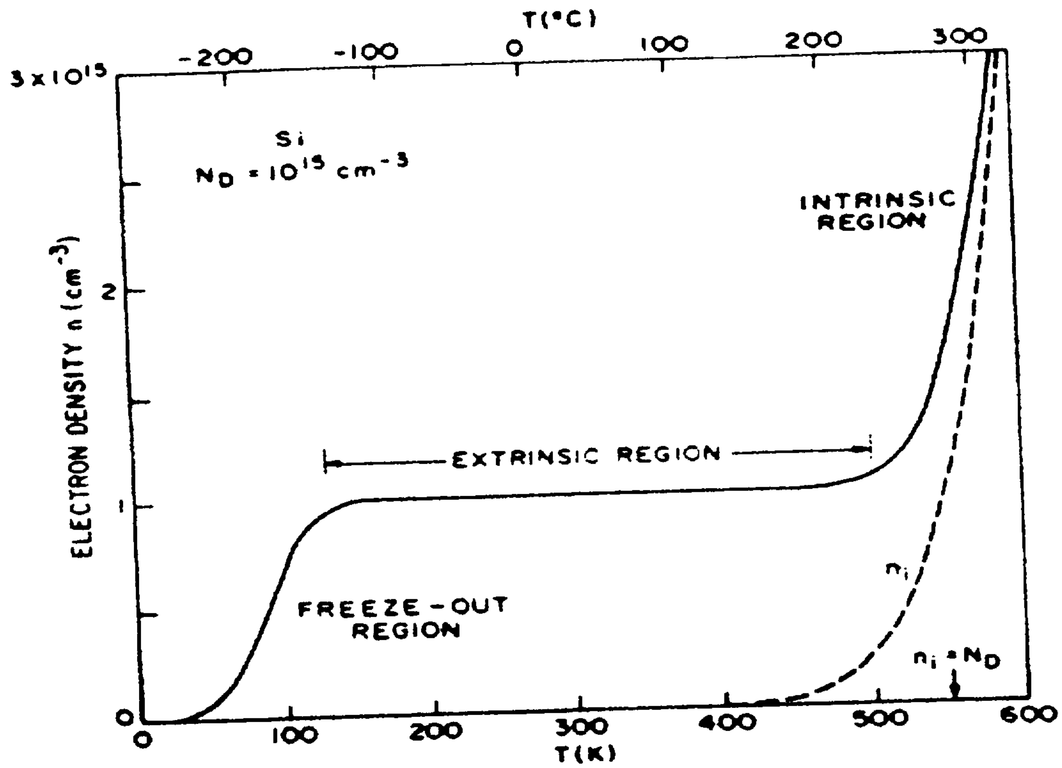
Carrier Concentration Versus Temperature



Electron Density versus Temperature for p-doped Silicon. Source: S.M.Sze, "Semiconductor Devices:Physics and Technology"

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Radioisotope Heating Units (RHU's)

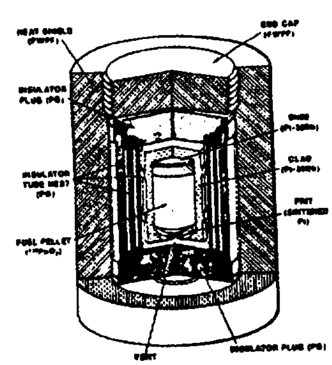
Cost per RHU: $30K
Weight per RHU: 40g

ecent Missions Using RHU's

ssion	RHUs used	RHU Cost ($M)	RHU Weight (Kg)
lileo	120	3.6	4.8
ssini	157	4.7	6.3

enefits of Wide/Low-Temperature ectronics

- Eliminate/reduce requirement for RHUs
- Reduce system weight and launch cost
- Simplify spacecraft design by eliminating containment/support structures for RHU's



Light-Weight Radioisotope Heater Unit

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Wide/Low Temperature Power Electronics Program

- Support the development of power systems capable of reliable, efficient operation over the temperature ranges of:
  - near room temperature (+200 C to -100C)
  - wide temperatures (+100 C to -175 C)
  - cryogenic temperatures (70 K to 20 K).

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IRF541 n-Channel HEXFET MOSFET

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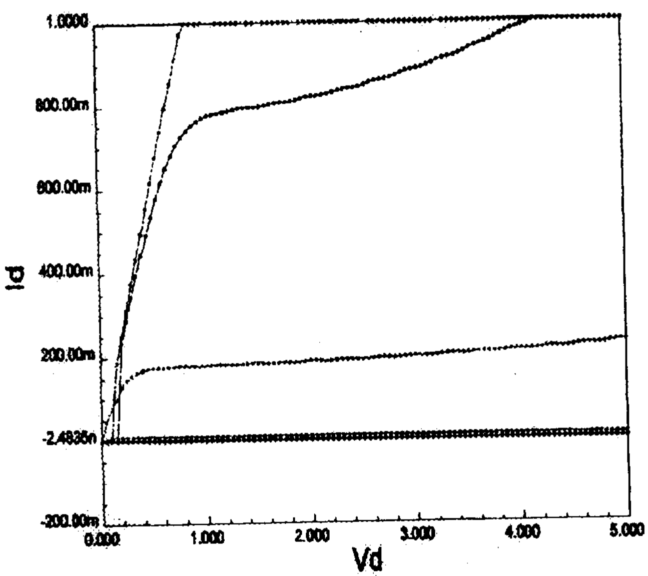
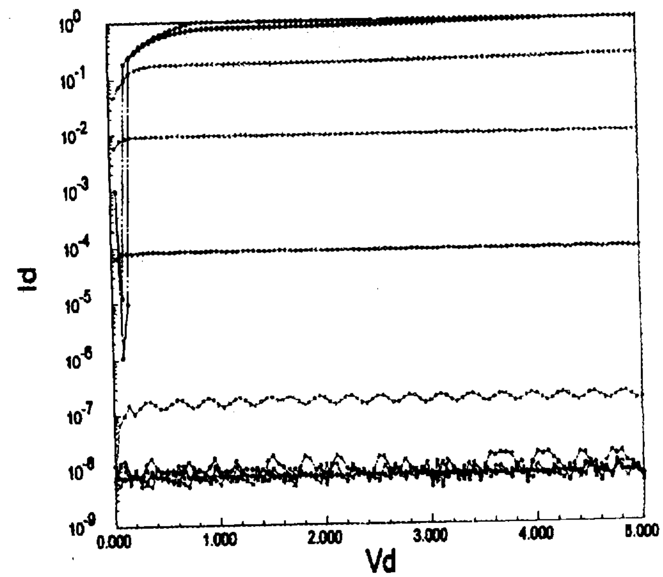
Drain Family at Room Temperature





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IRFD024 n-Channel HEXFET MOSFET: S/D Breakdown

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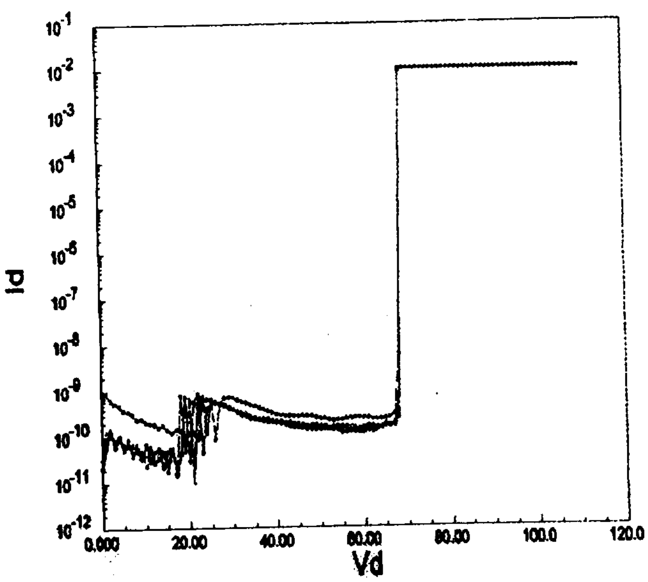
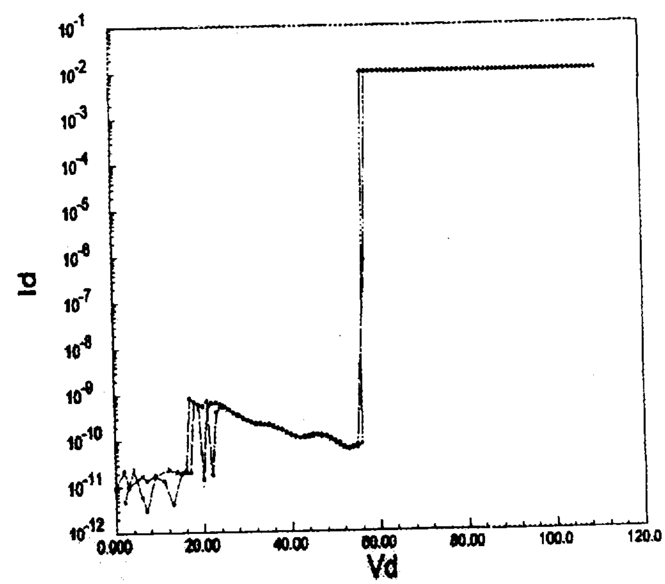
RT Breakdown = 69V



LN2 Breakdown = 57V



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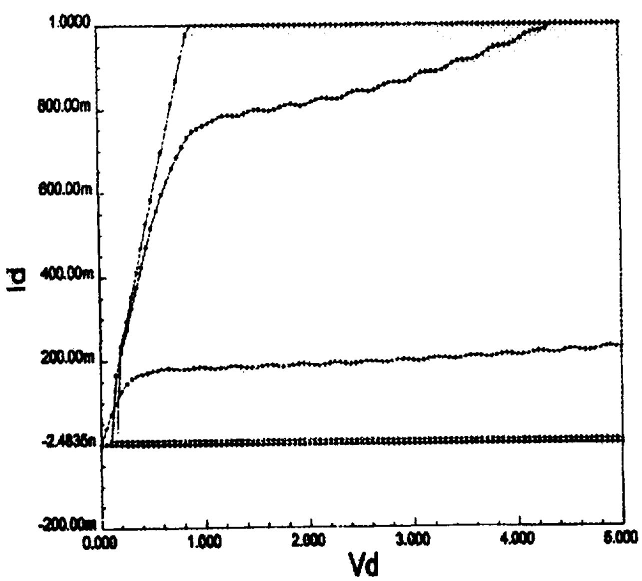
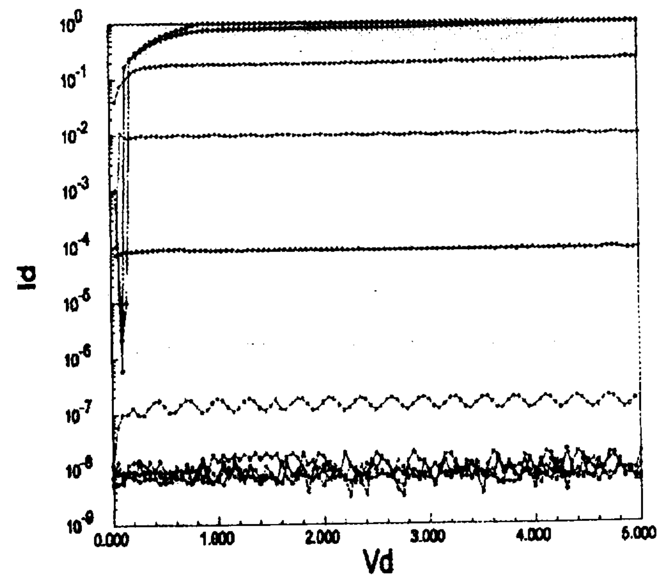
IRF541 HEXFET Success

Drain Family at RT after 10 LN2 Cycles





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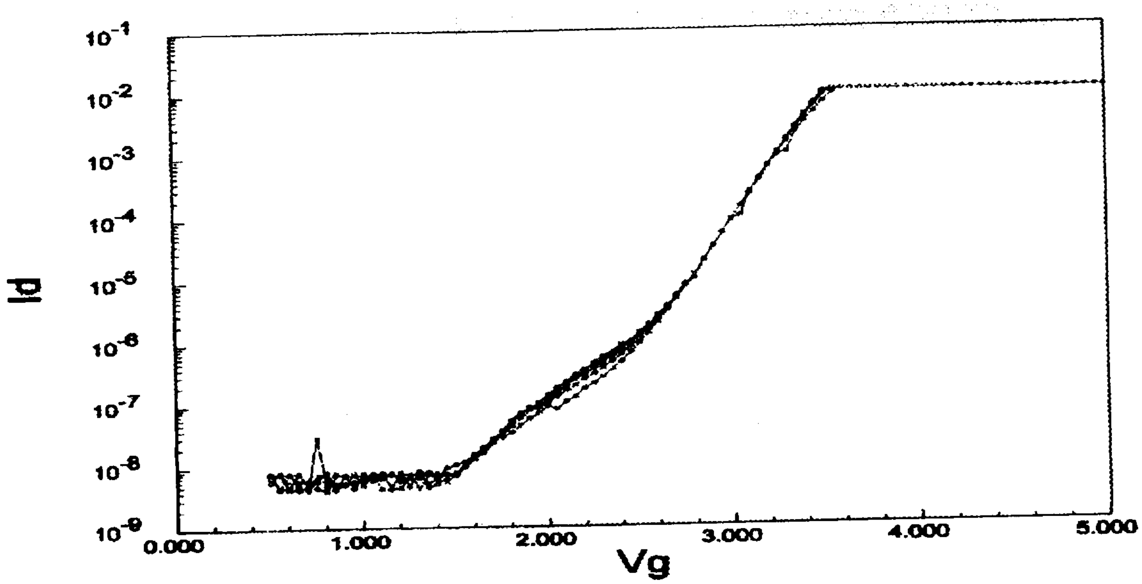
IRF541 HEXFET Success

RT Sub-Threshold Current after 10 LN2



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NE76118 n-Channel GaAs MESFET: Drain Family

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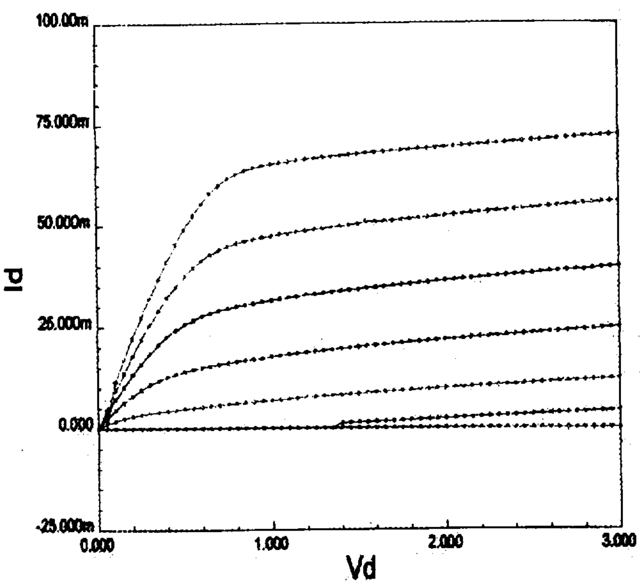
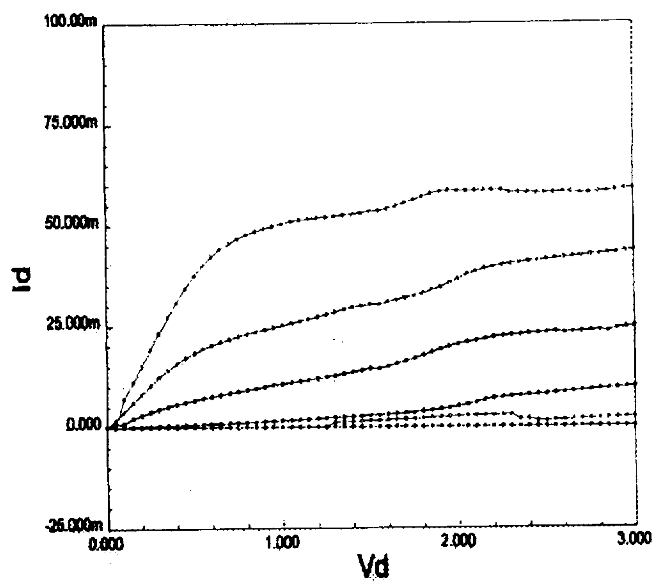
Room Temperature



Liquid Nitrogen



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NE76118 n-Channel GaAs MESFET: Thermal Cycle Failure

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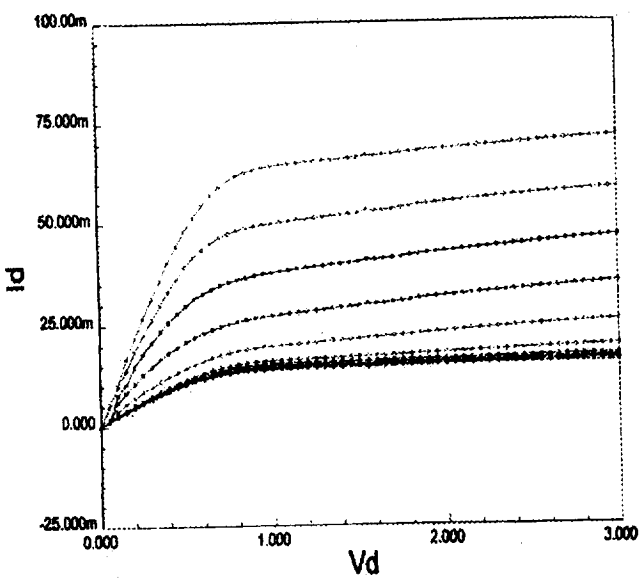
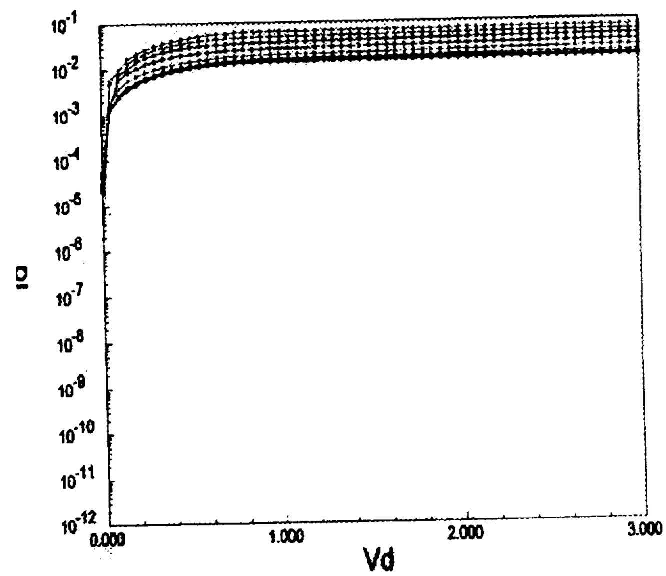
Drain Family at Room Temperature



Post 3rd LN2 Cycle



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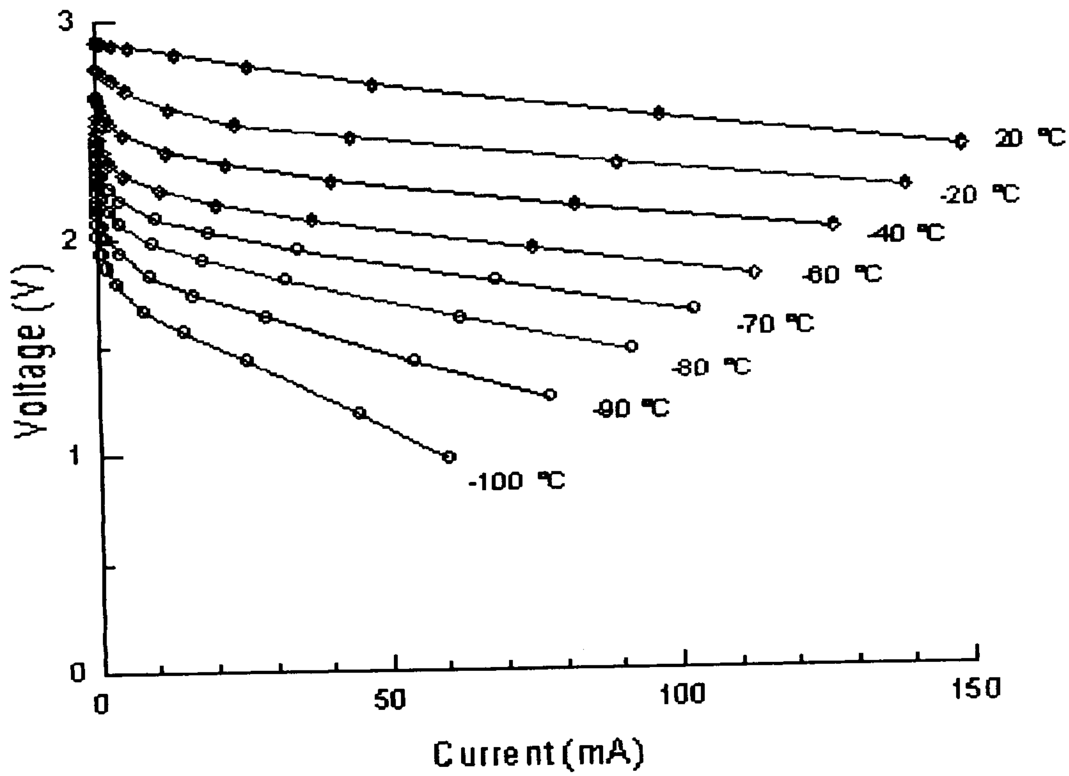
Lithium Carbon Monofluoride Primary Battery as a Function of Temperature



I-V characteristics of lithium carbon monofluoride primary battery at various loads as a function of temperature.

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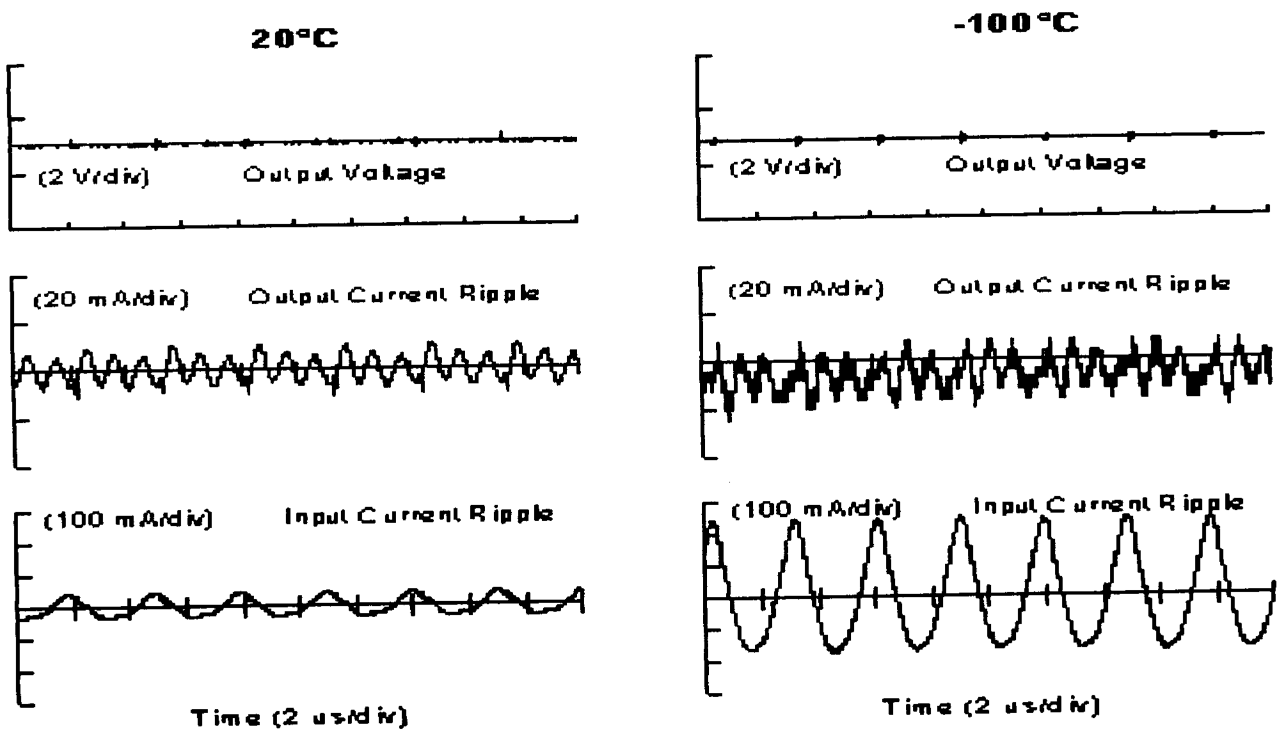
COTS DC-DC Converter



nverter characteristic waveforms with 36V input and 2.5 A load conditio

Conclusions

Preliminary results of wide/low-temperature testing of COTS and custom parts and power circuits indicate that through careful selection of components and technologies, it is possible to design and build power circuits which operate from room temperature to near 100K.

But ...

Challenges

Thermal Cycling

Radiation

Energy Storage

Batteries